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(54) METHODS FOR CUTTING BONE

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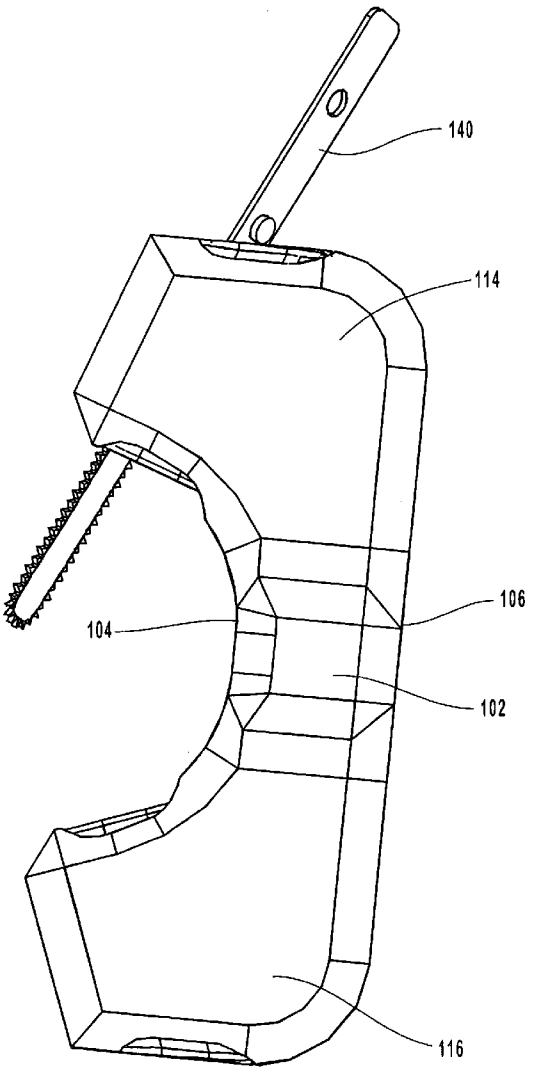
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(52) **U.S. Cl.** **606/87**

(57) **ABSTRACT**

A method of cutting bone with a bone die cutter includes positioning complementary cutting dies on at least substantially opposing sides of a bone. At least one of the cutting dies is pressed toward the other so that the cutting dies cut a bone portion from the bone. The cut bone portion is separated from the remainder of the bone. The cut bone portion is subsequently reattached to the bone at the location from which it was removed.



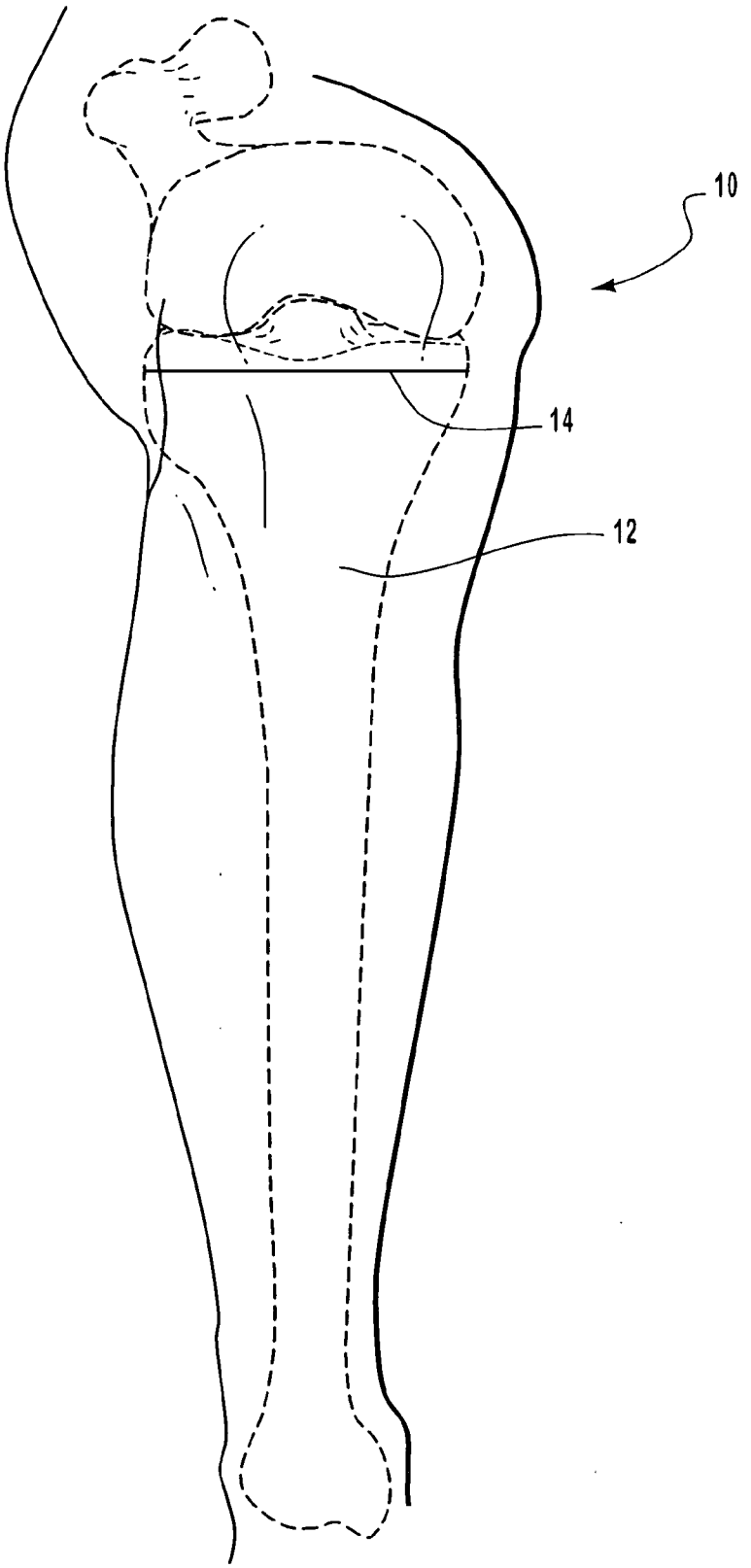


Fig. 1

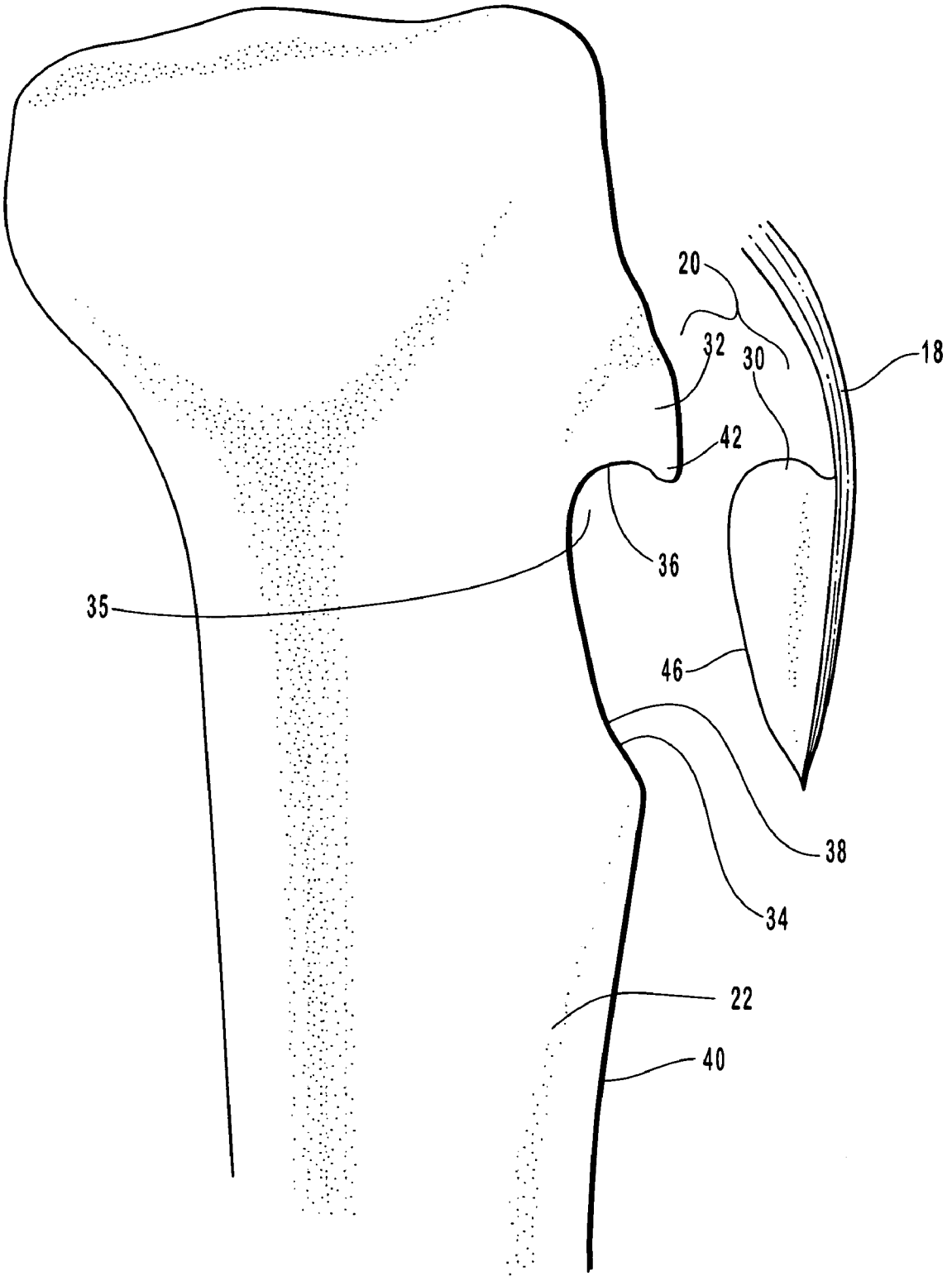


Fig. 2

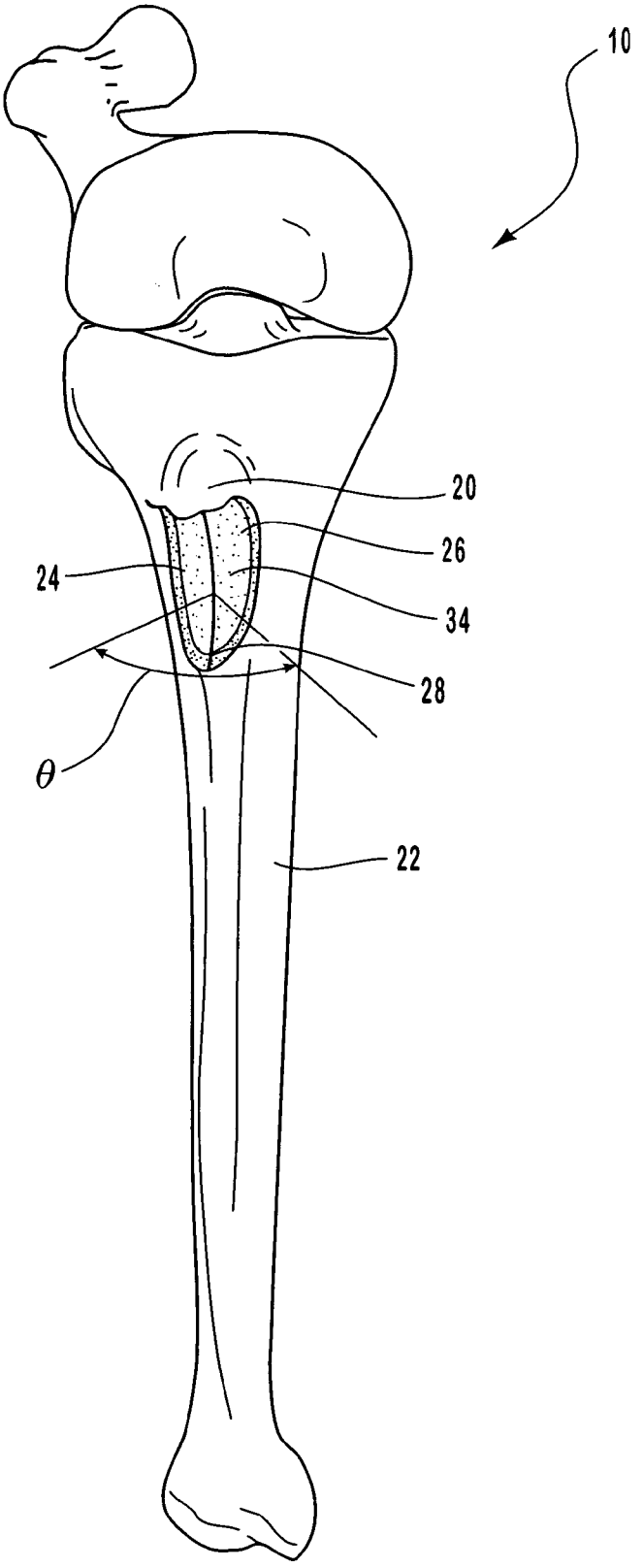


Fig. 3

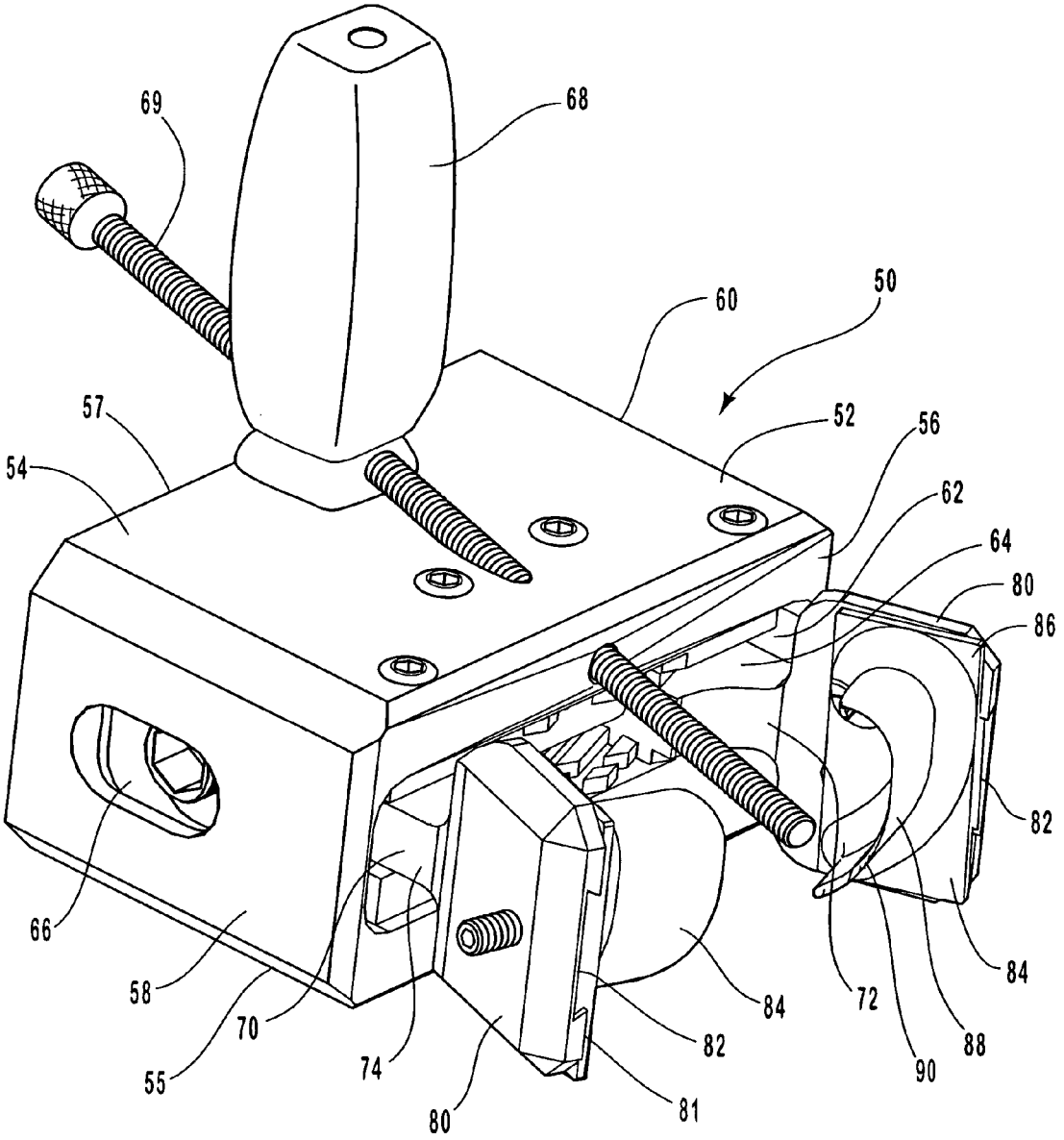

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Fig. 4

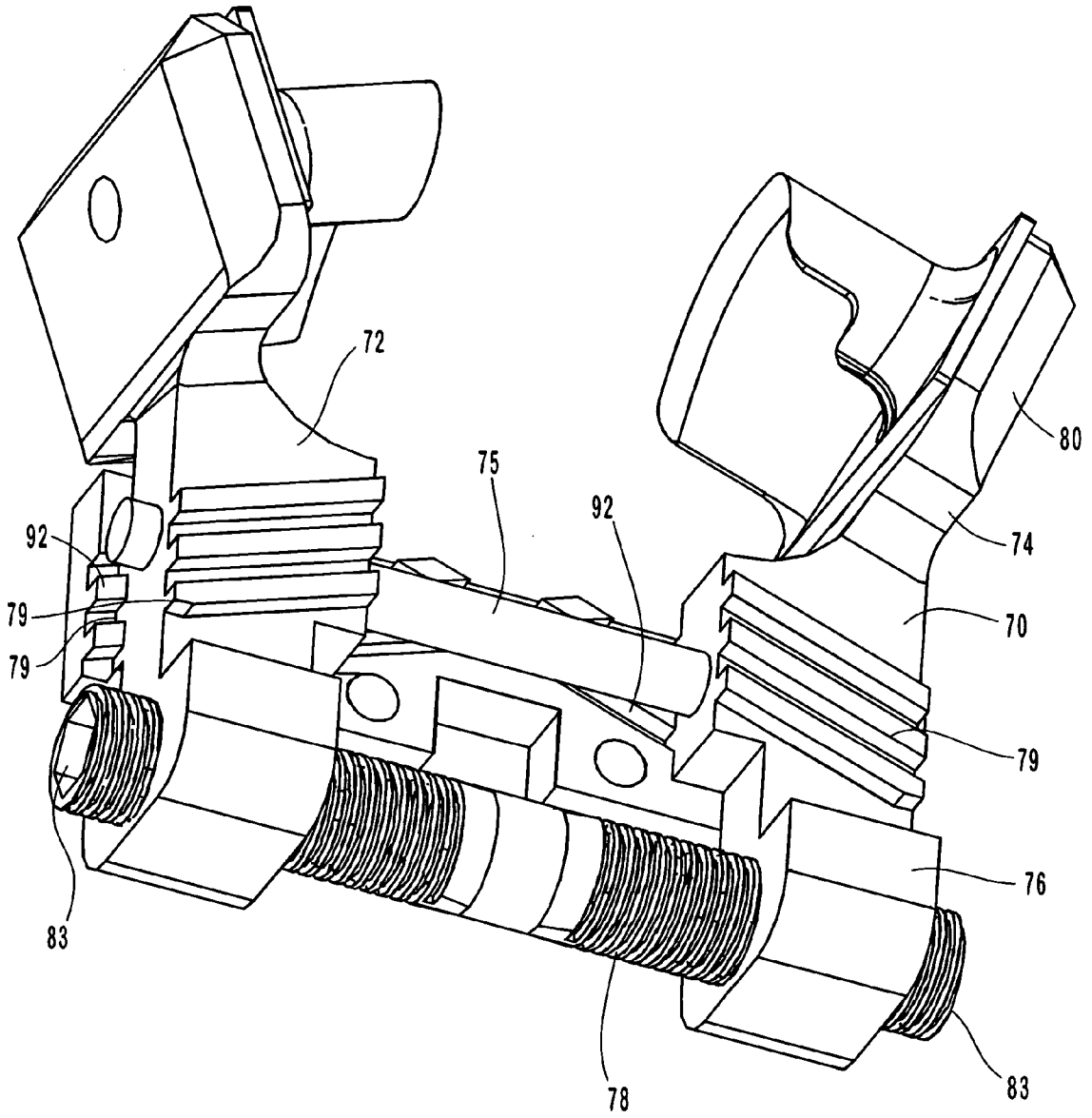


Fig. 5

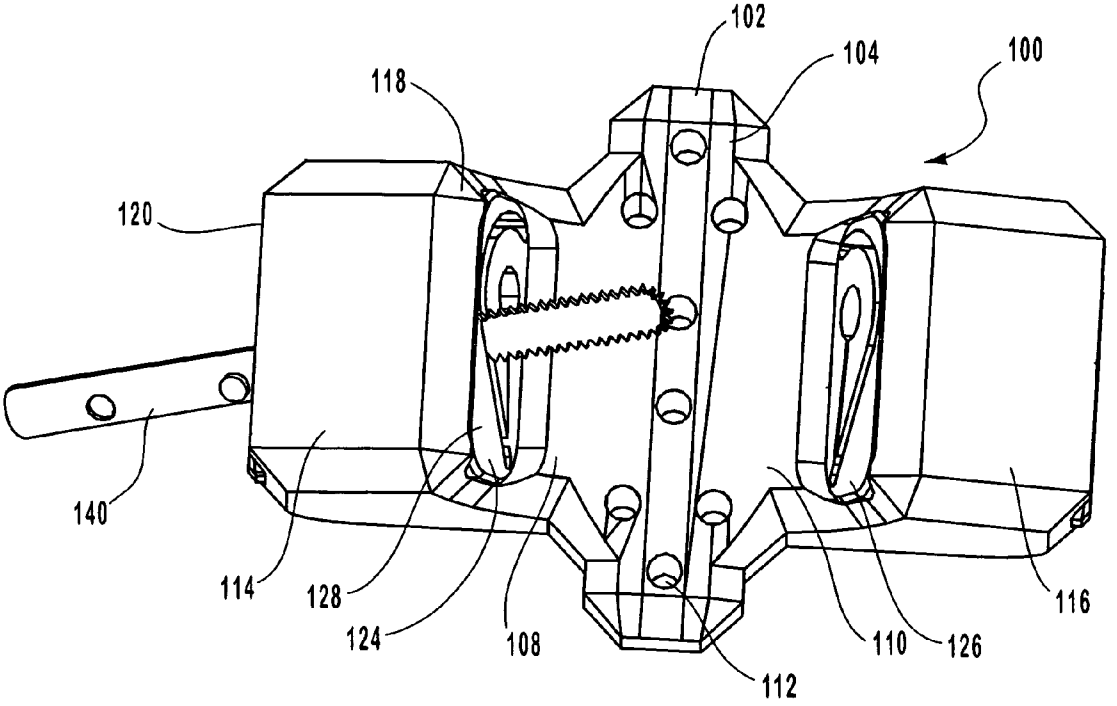

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Fig. 6

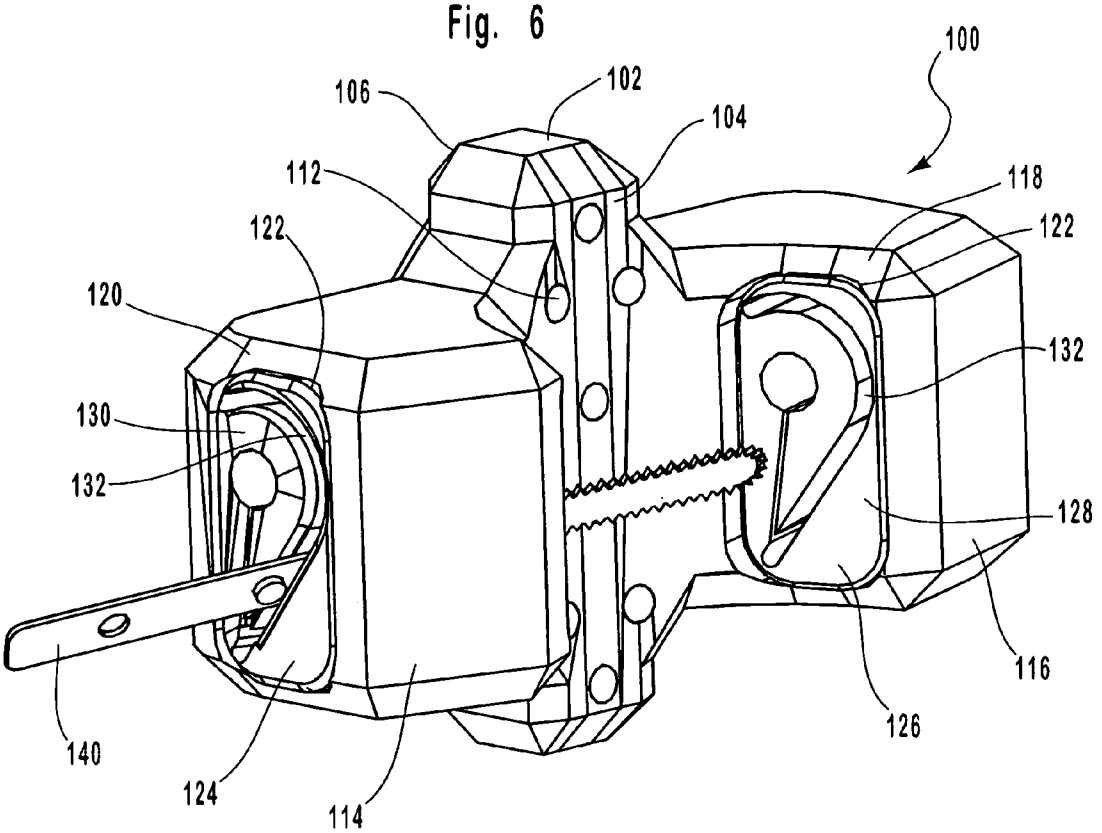

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Fig. 7

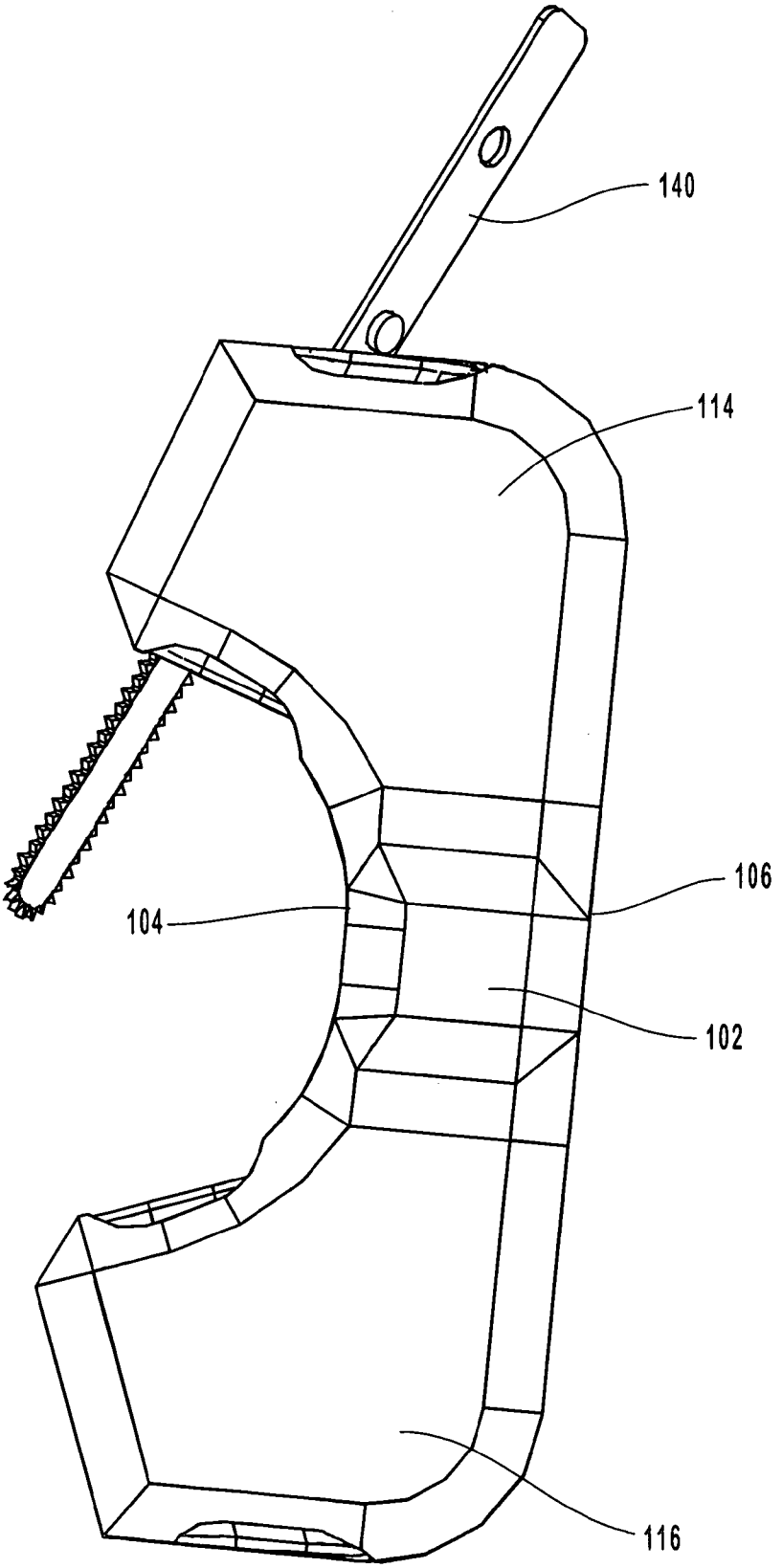


Fig. 8

METHODS FOR CUTTING BONE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a divisional of U.S. patent application Ser. No. 10/360,250, filed Feb. 6, 2003, which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. The Field of the Invention

[0003] The present invention relates to methods for cutting bone using complementary cutting dies. The method can be used for gaining surgical access to the knee cavity by performing a tibial tubercle osteotomy as part of a minimally invasive total or partial knee arthroplasty or other knee related surgery.

[0004] 2. Related Technology

[0005] As a result of accident, deterioration, or other causes, it is often necessary to surgically replace all or portions of a knee joint. Joint replacement is referred to as arthroplasty. Conventional total knee arthroplasty requires a relatively long incision that typically extends longitudinally along the lateral side of the leg spanning across the knee joint. To allow the use of conventional techniques, instruments, and implants, the incision typically extends proximal of the knee and into the muscular tissue. In general, the longer the incision and the more muscular tissue that is cut, the longer it takes for the patient to recover and the greater the potential for infection.

[0006] Accordingly, what is needed are minimally invasive procedures and corresponding apparatus for accessing the knee joint to perform total or partial knee arthroplasty.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Various embodiments of the present invention will now be discussed with reference to the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope.

[0008] **FIG. 1** is an elevated front view of a leg in a bent position;

[0009] **FIG. 2** is a elevated front view of a tibia of the leg shown in **FIG. 1** with a portion of the tibial tuberosity removed;

[0010] **FIG. 3** is an elevated side view of the tibia shown in **FIG. 2**;

[0011] **FIG. 4** is a perspective view of a die cutter;

[0012] **FIG. 5** is a perspective view of the arm assembly of the die cutter shown in **FIG. 4**;

[0013] **FIG. 6** is an elevated front view of a guide;

[0014] **FIG. 7** is a perspective view of the guide shown in **FIG. 6**; and

[0015] **FIG. 8** is a top plan view of the guide shown in **FIG. 6**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] The present invention relates to methods and corresponding instruments for performing a tibial tubercle osteotomy to gain access to the knee cavity as part of a minimally invasive total or partial knee arthroplasty or other knee related surgery. By way of example and not by limitation, depicted in **FIG. 1** is a knee **10** having an anterior side **12**. Knee **10** is flexed to about 90 degrees. A transverse incision **14**, approximately 10 cm long, is made mediolaterally through the skin layer across the midline of knee **10** proximal of the tibial tuberosity. As depicted in **FIG. 2**, the tissue is retracted exposing in part a patellar ligament **18** and a tibial tuberosity **20** of a tibia **22**. A portion of tibial tuberosity **20** connected to patellar ligament **18** is now elevated such that patellar ligament **18** remains connected thereto.

[0017] Specifically, **FIG. 2** shows a lateral view of the proximal end of tibia **22**. A distal portion **30** of tibial tuberosity **20** has been elevated while a proximal portion **32** of tibial tuberosity **20** remains integral with tibia **22**. Patellar ligament **18** is excised from proximal portion **30** of tibial tuberosity **20** so that the distal end of patellar ligament **18** can be freely elevated in connection with distal portion **30** of tibial tuberosity **20**. In one embodiment, distal portion **30** of tibial tuberosity **20** is sized such that between about ⅓ to about ½ of the central mediolateral width of patella ligament **18** and tibial tuberosity **20** is osteotimized from the proximal end of tibia **22**. Thus about ⅓ to about ½ of the distal contact surface of patellar ligament **18** remains connected to distal portion **30** of tibial tuberosity **20**.

[0018] Tibia **22** has an anterior cut surface **34**. With reference to the lateral side view of tibia **22** depicted in **FIG. 2**, cut surface **34** includes a proximally arched undercut portion **36** formed on the distal end of proximal portion **32** of tibial tuberosity **20**. As a result of cut surface **34**, proximal portion **32** of tibial tuberosity **20** terminates at a distally projecting anterior ridge **42**.

[0019] Cut surface **34** also includes a distally sloping portion **38** extending from undercut portion **36** to an anterior border **40** of tibia **22**. Cut surface **34** partially bounds a pocket **35** and has a transverse configuration taken along a plane extending proximal to distal that is similar to a vertically bisected heart design as depicted on conventional playing cards. In contrast to forming a smooth bisected heart shape design, cut surface **34** can also form a sharp or slightly rounded inside angle that is typically 90° or less.

[0020] As depicted in **FIG. 3**, cut surface **34** also has a substantially wedged shaped transverse configuration taken along a plane extending anterior to posterior. Specifically, cut surface **34** comprises a lateral side **24** and an opposing medial side **26** that each slope inwardly so as to intersect at a vertical midline **28**. In one embodiment, the inside angle θ between lateral side **24** and medial side **26** is in a range between about 60° to about 120° with about 80° to about 100° being more preferred. In alternative embodiments, cut surface **34** can be substantially flat extending mediolaterally or can form a rounded groove.

[0021] Elevated distal portion **30** of tibial tuberosity **20** has a cut surface **46** that is complementary to cut surface **34**. As will be discussed below in greater detail, one of the

benefits of the configuration of cut surfaces **34** and **46** is that once the procedure is complete, distal portion **30** of tibial tuberosity **20** is easily reinserted within pocket **35**. The complementary mating with undercut surface **36** helps lock distal portion **30** within pocket **35** as distal potion **30** is pulled proximal by patellar ligament **18**.

[**0022**] Distal portion **30** of tibial tuberosity **20** can be elevated using a number of different techniques. By way of example and not by limitation, depicted in **FIG. 4** is one embodiment of a die cutter **50** incorporating features of the present invention. Die cutter **50** comprises a housing **52** having a substantially box shaped configuration. Housing **52** has a front face **56** and an opposing back face **57** with side faces **58** and **60** extending therebetween. A top face **54** and an opposing bottom face **55** also extend between faces **56** and **57**. Housing **52** bounds a chamber **62**. Chamber **62** communicates with the exterior through an elongated slot **64** formed on front face **52** and an opening **66** formed on each side face **58** and **60**.

[**0023**] A handle **68** outwardly projects from top face **54** of housing **52**. A threaded alignment bolt **69** passes through handle **68** and a portion of housing **52** so as to centrally project beyond front face **56** of housing **52**. Alignment bolt **69** threadedly engages with handle **68** and/or housing **52** such that selective rotation of alignment bolt **69** facilitates selective positioning of alignment bolt **69** beyond front face **56** of housing **52**.

[**0024**] Partially disposed within chamber **62** of housing **52** are a pair of translating arms **70** and **72**. As depicted in **FIG. 5**, each translating arm **70** and **72** has a distal end **74** and an opposing proximal end **76**. In one embodiment of the present invention, means are provided for selectively advancing at least one of the first and second translating arms **70**, **72** toward the other. By way of example and not by limitation, a shaft **78** has threads formed along each end thereof with the threads being oriented in opposing directions. Each translating arm **70** and **72** is threaded onto a corresponding end of shaft **78**. Accordingly, selective rotation of shaft **78** causes translating arms **70**, **72** to either move together or move apart. A socket **83** is formed on each end face of shaft **78**. Shaft **78** is selectively rotated by inserting a tool, such as a drill bit, through one of openings **66** (**FIG. 4**) of housing **52** and into socket **83** of shaft **78**. Rotation of the tool thus facilitates rotation of shaft **78**.

[**0025**] In alternative embodiments for the means for selectively advancing, it is appreciated that shaft **78** can be replaced with a variety of other conventional threaded shaft or bolt mechanisms. Furthermore, shaft **78** can be replaced with elongated levered handles or other conventional apparatus that facilitate manual movement of translating arms **70** and **72**. In yet other embodiments, it is appreciated that hydraulic, pneumatic, or electrical mechanisms can be used for movement of translating arms **70** and **72**.

[**0026**] A plurality of spaced apart rails **79** outwardly project from each side of each translating arm **70**, **72**. Rails **79** mesh with complementary rails **92** formed on the interior of housing **52**. The meshing of rails **79** and **92** helps to ensure that translating arms **70**, **72** are maintained in alignment during movement. Proper alignment of translating arms **70**, **72** is further maintained by a pin **75** slidably extending through each of translating arms **70**, **72**.

[**0027**] Returning to **FIG. 4**, distal end **74** of each translating arm **70**, **72** extends outside of chamber **62** through slot **64**. Mounted at distal end **74** of each translating arm **70** and **72** is an outwardly sloping head plate **80**. Each head plate **80** has an interior face **81** with an undercut engagement slot **82** formed thereon. Each interior face **81** is disposed in a corresponding plane. The planes intersect so as to form an inside angle that is substantially equal to the angle θ formed on cut surface **34**. Slidably disposed within each slot **82** is a die **84**. Each die **84** has a base **86** that is connected with a corresponding head plate **80** by being slidably engaged within slot **82**. As a result, dies **84** can be easily replaced with new dies or with dies having an alternative configuration.

[**0028**] A blade **88** outwardly projects from each base **86** so as to extend orthogonally from interior face **81** of the corresponding head plate **80**. Each blade **88** terminates at a free sharpened edge **90**. Each blade **88** and corresponding sharpened edge **90** has a profile that is the same configuration as the profile of cut surface **34** of tibial tuberosity **20** previously discussed. Blades **88** are disposed so as to opposingly face at an intersecting angle. Accordingly, as shaft **78** is selectively rotated, translating arms **70**, **72** move together causing sharpened edges **90** to mate together.

[**0029**] During use, once tibial tuberosity **20** is exposed as discussed above, die cutter **50** is positioned such that dies **84** are positioned on the lateral and medial side of tibial tuberosity **20**. The free end of bolt **69** rests against the anterior surface of tibial tuberosity **20** and helps to facilitate proper positioning of dies **84**. In this regard, bolt **69** functions as a spacer. In alternative embodiments, bolt **69** can be replaced with a variety of other mechanism that permit selective spacing adjustment. For example, a rod and clamp configuration can be used.

[**0030**] Once die cutter **50** is appropriately positioned, shaft **78** is selectively rotated, such as by the use of a drill, so that translating arm **70** and **72** are advanced together. In so doing, the dies **84** penetrate laterally and medially into tibial tuberosity **20**. Dies **84** continue to advance until distal portion **30** of tibial tuberosity **20** is separated from proximal portion **32** thereof.

[**0031**] One of the benefits of using this process is that dies **84** produce very clean cut surfaces **34** and **46** with minimal bone loss. As a result, once the subsequent surgical procedure is completed, distal portion **30** can be fit back into pocket **35** with a close tolerance fit. It is appreciated that a variety of alternative configurations of die cutters can be used for selective die cutting of tibial tuberosity **20**.

[**0032**] In contrast to die cutting tibial tuberosity **20**, distal portion **30** of tibial tuberosity **20** can also be elevated using a saw blade. For example, depicted in **FIGS. 6-8** is a guide **100**. Guide **100** comprises a central plate **102** having a front face **104** and an opposing back face **106**. Each of faces **104** and **106** extend between opposing sides **108** and **110**. Extending between front face **104** and back face **106** are a plurality of passageways **112**.

[**0033**] Formed on sides **108** and **110** of central plate **102** is a first side housing **114** and a second side housing **116**, respectively. Each side housing **114** and **116** is formed so as to project beyond front face **104** of central plate **102**. Each of side housings **114** and **116** has an inside face **118** and an opposing outside face **120**. A cavity **122** extends through each of side housings **114** and **116** between faces **118** and

120. Removably disposed within cavity 122 of side housing 114 is a first template 124. A second template 126 is disposed within cavity 122 of side housing 116. Each template 124 and 126 has a substantially box-shaped configuration which includes an inside face 128 and an opposing outside face 130. Inside face 128 of templates 124 and 126 are each disposed in a corresponding plane. The planes intersect so as to form an inside angle that is substantially equal to the angle θ formed on cut surface 34.

[0034] A guide slot 132 extends through each of templates 124 and 126 between inside face 128 and outside face 130. Each guide slot 132 has a configuration complementary to the profile of cut surface 34 and extends through templates 124 and 126 at an orientation perpendicular to inside face 128.

[0035] During use, once tibial tuberosity 20 is exposed, front face 104 of central plate 102 is biased against the anterior side of tibial tuberosity 20 such that templates 124 and 126 are disposed on the lateral and medial side thereof. Guide slots 132 are aligned with distal portion 30 of tibial tuberosity 20 to be elevated. Once guide 100 is appropriately positioned, fasteners, such as screws, nails, or the like, are passed through passageways 112 and into tibia 22 so as to securely retain guide 100 to tibia 22. It is noted that passageways 112 are sloped such that the fasteners extending therethrough extend into portions of tibia 22 outside of distal portion 30 which is to be elevated.

[0036] Once guide 100 is positioned in place, a saw blade 140 is passed through guide slot 132 of template 124 from outside face 130 to inside face 128. Saw blade 140 is moved in a reciprocating manner so as to penetrate half way into tibial tuberosity 20. Once the reciprocating saw blade 140 has completed passage along guide slot 132, saw blade 140 is moved over to template 126 and passed through the guide slot 132 thereof. The process is then repeated. Once both cuttings are performed, distal portion 30 of tibial tuberosity 20 is freely removable from the remainder of tibia 22. The fasteners are then removed along with guide 100. As with die cutters 50, it is appreciated that guide 100 can come in a variety of alternative configurations.

[0037] As previously mentioned, once distal portion 30 of tibial tuberosity 20 is elevated, patellar ligament 18 is retracted proximally, thereby exposing the knee joint. Once the knee joint is exposed, any number of knee related surgical procedures, such as total or partial knee arthroplasty, can be performed. Referring back to FIG. 2, upon completion of the surgical procedure, patellar ligament 18 is secured back in place by inserting distal portion 30 of tibial tuberosity 20 back into pocket 35. As a result of undercut portion 36, distal portion 30 of tibial tuberosity 20 is self-locking within pocket 35. If desired, however, various types of conventional bone anchors can be used to further secure distal portion 30 of tibial tuberosity 20 within pocket 35.

[0038] The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed is:

1. A method of cutting bone with a bone die cutter, the method comprising:

positioning complementary cutting dies on at least substantially opposing sides of a bone;

pressing at least one of the cutting dies toward the other so that the cutting dies cut a bone portion from the bone;

separating the cut bone portion from the bone; and

reattaching the cut bone portion to the bone.

2. A method as recited in claim 1, wherein the act of separating the cut bone portion forms a recessed pocket on the bone, the cut bone portion being reattached into the recessed pocket.

3. A method as recited in claim 1, wherein the recessed pocket includes an undercut portion.

4. A method as recited in claim 1, further comprising the act of performing a surgical procedure between the acts of separating and reattaching.

5. A method as recited in claim 1, wherein the cutting dies are positioned on opposing lateral and medial sides of a tibial tubercle such that the cut bone portion comprises at least a portion of the tibial tubercle.

6. A method as recited in claim 5, further comprising performing a total knee arthroplasty or a partial knee arthroplasty between the steps of separating and reattaching.

7. A method as recited in claim 1, wherein the cutting dies are positioned on opposing sides of a distal portion of a tibial tubercle such that the separated cut bone portion comprises the distal portion of the tibial tubercle while a proximal portion of the tibial tubercle remains attached to the tibia.

8. A method as recited in claim 7, wherein the distal portion of the tibial tubercle is separated from the tibia so that at least a portion of a patella ligament remains attached to the distal portion of the tibial tubercle.

9. A method as recited in claim 8, wherein the distal portion of the tibial tubercle is separated from the tibia so that a recessed undercut pocket is at least partially formed on the proximal portion of the tibial tubercle.

10. A method as recited in claim 1, wherein each of the dies has a blade projecting therefrom, the act of positioning the complementary cutting dies comprising positioning the dies so that the blades intersect at an angle when the blades are brought together.

11. A method as recited in claim 1, wherein each of the dies has a transverse cross sectional configuration that corresponds substantially to the contour of an exterior surface of a vertically bisected heart design.

12. A method as recited in claim 1, wherein the step of positioning complementary cutting dies comprises positioning a die cutter adjacent to the bone, the die cutter comprising a housing having a pair of translation arms extending therefrom, each cutting die being disposed at the end of a corresponding translation arm.

* * * * *